CHLASTS project

Chemical Laboratory Safety Training System

Chemical waste disposal

Education and Culture
Leonardo da Vinci

Index

1. Introduction

Chemical laboratories at schools and universities are dedicated to the education of a safe, healthy and productive chemistry. As part of the commitment to environmental health and safety, we strive to ensure that students, faculty and staff meet or exceed European Union legislation concerning hazardous wastes, laboratory management and worker safety.

Proper storage and disposal of laboratory waste is a key element of this commitment. If you generate or handle wastes, it is incumbent upon you to follow the established guidelines concerning the proper disposal of hazardous waste.

Almost all things used in laboratory for example: samples, reaction products, filtrates, residues, solvents, chemicals, glassware, empty packaging, broken thermometers, computers and other equipment at some point will become a waste – mostly **hazardous waste**.
As in other areas, waste avoidance is an important environmental, safety and cost factor. Because of that, all the waste coming out from the laboratory should be properly disposed.

Moreover, we must continuously evaluate our processes, looking for ways to minimize our impact on the environment by reducing and recycling waste whenever possible.

The purpose of this book is to assist you in proper handling and disposal of hazardous chemical waste. If at any time you are unsure how to deal with wastes, immediately consult your supervisor or one of the safety officers.

2. General information

2.1. Waste

There are four major categories of waste generated at the university or school:

- radioactive waste
- chemical waste
- infectious waste
- domestic waste

2.2. Hazardous chemical waste

There are three main classifications of hazardous waste (*HAZARDOUS WASTE DIRECTIVE* -91/689/EEC). Hazardous waste can be classified by:

1. CATEGORIES OR GENERIC TYPES OF HAZARDOUS WASTE
(IA: 1-18; IB: 19-40)
2. CONSTITUENTS OF THE WASTES
(C1-C51)
3. PROPERTIES
(H1- H14)

The List of Wastes is established with *Commission Decision 2000/532/EC of 3 May 2000* (). The European Waste List is a harmonised list of wastes. The List of Wastes contains both hazardous and non-hazardous wastes. Any waste marked in the list with an asterisk (*) is considered as hazardous waste.

Almost any chemical requiring disposal is a hazardous waste, which needs to be disposed of following the procedures listed in this handbook.

General rule:

Do not mix different categories of hazardous waste
or mix hazardous waste with non-hazardous waste.

Hazardous chemical waste includes the following:

- Chemicals that can no longer be used for their intended use.
- Chemical waste generated from research and educational experiments and procedures.
- Mislabeled or unlabeled chemicals.
- Abandoned chemicals.
- Material in deteriorating or damaged containers.
- Residuals in chemical containers.
- Laboratory trash and personal protective equipment contaminated with chemicals.
- Debris contaminated with a hazardous material (rags, paper towels, lab diapers, gloves, etc.).
- Non-returnable gas cylinders.
- Batteries.
- Spent solvents, stains, strippers, thinners, varnish, and wood preservatives.
- Used oil of all types.
- Discarded equipment containing hazardous materials.
- Photographic film processing solutions.
- Pesticides, herbicides, fertilizers.
- Formaldehyde and formalin solutions.
- Mercury containing items (other heavy metals).
- Liquid and acrylamide gel waste.
- Sharps (syringes, needles, GC syringes, razor blades, pasteur pipettes, pipette tips).
- Unused and surplus cleaners.
- Bleach, windex, ammonia, carpet cleaners, disinfectants, drain cleaners, oven cleaners, floor wax, floor and wood polishes, toilet cleaners, spot removers, etc.
- Computer and electronic equipment.

Strict sewer, air emissions, and landfill regulations require that hazardous waste is not drain disposed, evaporated in fume hoods, or disposed of in the normal trash.

3. Resposibilities

Chancellors, vice presidents, deans, directors, chairs and other heads of academic and administrative units have **a primary responsibility:**

- **for the health and safety of their staff and students;**
- for compliance with all applicable laws and regulations;
- for providing funds needed;
- for safety and health improvements;
- for making those improvements;
- for ensuring that supervisors, employees and students comply with the duties set forth in these regulations.

VIOLATIONS CAN RESULT IN SUBSTANTIAL FINES, OR EVEN THE CLOSING OF THE LABORATORY!

Laboratory personnel is responsible for the following:

- Identification of waste;
- Labeling of waste;
- Storage of waste;
- Transportation of waste to a pickup location or scheduling a pick-up;
- The principal investigator or lab manager is responsible for coordinating the disposal of all chemicals from their laboratories **prior** to closing down laboratory operations.

The principal investigator or supervisor is responsible for:

- providing and documenting on-the-job training for employees;
- designate and mark special areas for collecting of hazardous waste;

- carefully select and become familiar with an individual chemical's hazards, and make every effort to manage and dispose of the waste products;
- proper identification, segregation, collecting, labeling of all waste products for final disposal;
- ensuring that all applicable sewer disposal guidelines are strictly adhered to before any waste products are flushed into any sink or drain;
- ensuring that different types of waste are not mixed together;
- training the personnel to clean up minor spills occurring in the laboratory;
- ensuring that the volume of waste is minimized as much as possible.

4. Classification and collecting of waste

GENERAL RULE

Chemical Waste Must Not Be Discarded:
Into sink drains
As general waste
Into Dumpsters
Into Storm Drains

4.1. Identification

If a waste meets one or more of the hazardous waste characteristics (some are listed in Annex I) it has to be considered a hazardous waste.

Chemical wastes display the same hazards as the chemicals from which they are generated. Occasionally dilution in the process may result in minimizing or eliminating the hazard, but a waste determination is required before you can call your waste non-hazardous. If you are uncertain of the hazard, it is most likely a "Toxic" waste due to the very strict legislation criteria.

4.2. Segregation

In general:

- segregate LIQUIDS from DRY waste
- segregate REACTIVES from IGNITABLES
- segregate ACIDS from ALKALINES
- segregate CORROSIVES from IGNITABLES
- segregate strong OXIDIZERS from EVERYTHING
- most ORGANIC REACTIVES must be segregated from INORGANIC REACTIVES

Do not mix wastes, especially a hazardous waste with a non-hazardous waste. Accurately label the container as to its exact contents.

There are some general groups identical for all countries:

1. Liquid, organic halogenated;
2. Liquid, organic non halogenated;
3. Liquid inorganic halogenated;
4. Liquid inorganic non halogenated;
5. Solid flammable;
6. Solid non flammable;
7. Heavy metals;
8. Very toxic.

Before you dispose your waste to the container make sure it is the proper one

If you are not sure - ask your instructor or supervisor !

4.3. Incompatible wastes

Improper mixing of some types of waste could be very dangerous. It could be a source of many unexpected, violent, exothermic reactions, resulting even in fire, explosions or toxic gases emission

Listed in Annex II, TABLE I and TABLE II are examples of potentially incompatible wastes, waste components, and materials, along with harmful consequences which result from mixing materials in one group with materials in another group. This list is not exhaustive.

4.4. Pre-treatment

Some substances have to be carefully pre-treated before placing in the container. It particularly concerns: peroxides, cyanides, metallic sodium, potassium. Such very reactive chemicals should be neutralized.
You have to read carefully and follow the Standard Operating Procedures when working with such substances.

4.5. Neutralization

Some laboratories generate a simple, pure chemical stream, such as dilute acid or base that can be rendered non-hazardous by simple neutralization. Some dilute aqueous stream containing metal ions can be easily precipitated.

There are only few types of wastes, which are allowed to be poured out directly to the drain, after a proper neutralization. Before doing that always check the Waste Disposal Instruction.

4.6. Waste containers and labeling

All the wastes should be collected in **special containers** placed at **specially designated place** in laboratory. **The place should be clearly labeled and assigned only for them.**

Rules of waste classification and collecting can differ at particular Universities or countries, as well as can be regulated by additional local rules due to some special requirements.

Basic procedures:

1. Collect substances in the original or other suitable primary container.
2. Properly label containers as to contents and hazards.
3. Properly store containers until ready for disposal.
4. When accumulation exceeds the available storage limits within the laboratory area, arrange for the transfer of the substances.

Waste containers

All laboratory waste containers must be:

1. Made of material that is compatible with the contents;
2. In good condition with no leaks or cracks;
3. Kept closed except when adding waste;
4. Segregated from other incompatible wastes;
5. Stored in secondary containment;
6. Affixed with a completed Hazardous Waste Label.

Labeling of containers

1. Each container shall bear the chemical waste label which clearly and neatly indicates the chemical or common name of each substance in the mixture.

2. Indicate the strength or concentration of the substance where applicable.
1. Example: Hydrochloric Acid may have a strength of 10%, 28%, 38%.
2. Do not use chemical formulas, chemical symbols, chemical equations or abbreviations.
3. Indicate the physical and/or health hazards of the substance, if known.
4. Indicate the person responsible for generating the waste.
5. In the instances of time sensitive substances such as ethers, the date of container opening or initial accumulation shall be included on the form.
6. Remove or obliterate any other labels or wordings not related to the current substance.
7. Do not allow the creation of "UNKNOWNS" through lack of secure readable labeling.

4.7. Unknown chemical waste

Chemicals that cannot be identified are considered unknown hazardous waste. Unknown chemical wastes cannot be legally transported or disposed. In order to dispose of them safely and properly, it is important to know as much about the material as possible. Testing may need to be done to determine the characteristics of the waste. This testing is expensive and may be charged back to the department generating the waste.

Adhere to the following guidelines when unknown hazardous waste is found:

1. Contact safety office to inform them of the material in question.
2. Attempt to determine how the waste was generated *e.g.*by contacting researcher/professor who has left the University. The more information known about the waste, the easier it will be to characterize it for disposal.
3. If possible, perform diagnostics to determine the characteristics of the waste.
4. **DO NOT**
    a. Pour unknown chemicals down the sink,

b. Mix unknown chemicals with any other chemicals,
c. Abandon unknown chemicals in the work area.

It is easy to avoid generating unknown hazardous waste by doing the following:

1. Clearly label all chemicals in the laboratory.
2. Dispose of spent materials or unwanted chemicals promptly.
3. Before moving out of your laboratory, ensure all chemicals are identified properly and all waste is disposed of prior to leaving.
4. Do not leave chemicals behind when you relocate from one laboratory to another unless arrangements have been made with the new occupant.

Solid Waste Streams

Solid waste includes any laboratory material that has come in contact with a chemical or is potentially contaminated with a chemical.

Examples:

- gloves,
- bench-top paper,
- weighing boats and papers,
- paper towels, clean up material,
- permanently contaminated glassware and plasticware.

Use the following procedures to manage solid chemical waste:

- Use proper container.
- All containers must have lids.
- Apply a completed chemical waste label on the outside of the container.

4.8. Other waste

4.8.1 Peroxides

Organic peroxides are a class of compounds with unusual stability problems and are one of the most hazardous classes of chemicals normally handled in the laboratory. Many common laboratory chemicals can form peroxides on exposure to air so that a single opening of the container can allow formation of peroxides to take place.

All peroxidizable compounds should be stored away from heat and light. They should be protected from ignition sources and physical damage. A **warning label** should be affixed to all peroxidizable compounds as illustrated below to indicate the date of receipt and the date the container was first opened.

Peroxidizable Compound	
Received	**Opened**
Date:	Date:
Discard or test within 6 months after opening.	

WARNING! If you notice that crystals have formed in a peroxidizable liquid, or discoloration has occurred in a peroxidizable solid, peroxidation may have occurred, and the product should be considered extremely dangerous and destroyed without opening.

All materials in Lists A, B, and C on the following table, should be evaluated according to the time frame listed below:

Common Compounds that Form Peroxides During Storage

List A - Red Label (Three Months) Peroxide Hazard on Storage	**List B** -Yellow Label (Twelve Months) **Peroxide Hazard on Concentration**	**List C** -Yellow Label (Twelve Months) **Hazard Due to Peroxide Initiation of Polymerization***
Divinyl acetylene	Acetal	Butadiene
Isopropyl ether	Cumene	Chlorotrifluoroethylene
Potassium metal	Cyclohexene	Chlorobutadiene
Sodium amide	Diacetylene	(Chloroprene)
Vinylidene chloride	Dicyclopentadiene	Styrene
	Dioxane	Tetrafluoroethylene
	Ethylene glycol dimethyl ether (glyme)	Vinyl acetate
	Ethyl ether	Vinyl acetylene
	Methyl acetylene	Vinyl chloride
	Methylcyclopentane	Vinyl pyridine
	Methyl i-butyl ketone	
	Tetrahydrofuran	
	Tetrahydronaphthalene	
	Vinyl ethers	

When stored as a liquid, the peroxide forming potential increases and certain of these monomers (especially butadiene, chloroprene, and tetrafluoroethylene) should then be considered as List A compounds.

4.8.2. Aerosol cans

Unwanted aerosol cans must be empty prior to disposal. Spray the can near zero contents before disposing of it in the regular trash. Some aerosol cans, such as paint, can be emptied by spraying the remaining contents onto a piece of cardboard and disposing of both items in the trash. Any aerosol can originally containing pesticides, toxic chemicals, or freons, must be given to EH&S as “Hazardous Waste”.

4.8.3. Batteries

All batteries should be considered a hazardous waste and should be disposed of accordingly.

4.8.4. Empty chemical containers

All empty containers should be triple-rinsed with water and air dried. After this procedure, they may be disposed of in the trash. If the container held a toxic or poisonous chemical, the container must be triple-rinsed with an appropriate solvent capable of removing the chemical. This rinsate must be collected and treated as “Hazardous Waste”. Triple-rinse the bottle with water again and let air dry. The container may be disposed of in the trash. Instead of throwing these containers in the trash, it may be best to reuse the container to collect compatible waste.
Relabel the container appropriately.

4.8.5. Gas cylinders

Gas cylinders should be returned to the manufacturer or distributor from whom they were purchased. Arrangements should be made at the time of purchase for the cylinder return. In the event, you find discarded cylinder bottles in your laboratory, an attempt should be made to contact the manufacturer for cylinder return information. Cylinders returned to the manufacturer must be shipped in approved containers.

4.8.6. Labware / glassware

Labware/Glassware can be disposed of in the regular trash unless contaminated with a toxic substance. If contaminated, package the waste into an appropriate container and label it as “Hazardous Waste”. The chemical contaminating the glassware must be listed on the hazardous waste label.

4.8.7. Silica gel/ desiccants

Silica gel and dessicants that are grossly contaminated must be disposed of as “Hazardous Waste”.

4.8.8. Thermometer / mercury waste

Liquid mercury can be recycled, however, the recycling costs are expensive. A mercury spill kit can be used. All vacuumed mercury must be transferred into an suitable container and labeled as “Hazardous Waste”.

5. External waste transport

Qualified institutions (with adequate permit) take waste for further proper disposal

6. Conclusions

The work in chemical laboratory is a lot of fun, but in order to make it completely safe to people and environment, and also to minimize the risk you have to follow carefully the safety rules (SOP and GLP).

6.1. Planning of experiments

In order to minimize environmental impact as well as disposal costs, the capacity of waste should be minimized.

YOU HAVE TO THINK AND PLAN BEFORE YOU START DOING ANYTHING IN THE LAB!

Follow the rule 3xR

Replace Reduce Recycle

REPLACE

When it is possible try to replace a method applying toxic substances with another one. Try also to replace toxic and mutagenic solvents with other (*showing similar properties in your experiment but not so harmful*).

Laboratory Product Substitution Opportunities

There are many chemical product substitution opportunities for laboratories. Please consider incorporating as many of the following into your research as practicable. The environment will benefit and so will your laboratory.

Cleaning/Sterilizing/Rinsing Substitution Opportunities:

- Lab glass cleaning: "No-Chromix," enzymatic cleaners, detergents, etc. instead of chromerge (sulfuric acid-sodium dichromate).
- Histology labs: alcohol fixative (less toxic) instead of formaldehyde and citric acid-based preparatory chemicals.
- Quaternary amine detergents instead of isopropyl alcohol as sterilizing agent for equipment, particularly in medical studies.
- Ethanol instead of methanol in dehydrating and rinsing processes.

Thermometer Substitution Opportunities:

- Alcohol/glycol instead of mercury.

Academic/Teaching Substitution Opportunities:

- Use of non-hazardous chemicals in chemistry teaching laboratories:

Other Substitution Opportunities:

- Compressed pure oxygen gas instead of compressed CFC gases for purging microtubing in optic ganglia physiology studies.
- Substitutes for organic solvents in liquid-liquid extraction or chromatography:
    - Supercritical carbon dioxide for organic solvents in high-performance chromatography;
    - Toluene for benzene (less toxic);
    - Methyl tert - butyl ether for diethyl ether (does not form explosive peroxides).
- Copper sulfate catalysts for mercury sulfate or selenium metal catalysts in Kjeldahl analyses.

Process Modification

To the extent it doesn't affect vital research, experimental or standard processes can be modified to decrease the quantity of hazardous chemicals used and generated. In laboratories, microanalysis techniques can greatly reduce the amount of waste generated. Maintenance shops can utilize parts washer solvent recycling programs to generate less solvent waste.

Product Modification

Whenever possible, substitute non-hazardous or less toxic materials in your chemical processes and experiments.

Laboratory Process Modification Opportunities

There are many chemical process substitution opportunities for laboratories. Please consider incorporating as many of the following into your research as practicable. The environment will benefit and so will your laboratory.

Analytical Equipment Modifications:

- Instrumentation and automation upgrades.
- Use of capillary columns in gas chromatographs instead of micropore or large-diameter columns, and capillary or micropore columns in high-performance liquid chromatography (HPLC) instead of large-bore columns.
- Smaller-volume, multielement standards purchased that can be used for both AA and ICP.
- TCLP: use of 1L of water to wash filtration vessel rather than 3L; use of a 25-mL extract rather than 50 mL.

Neutralization/Deactivation/Recovery:

- Adding a treatment or deactivation step to procedures.
- Adding distillation steps to experimental procedures to recover solvents.
- Neutralizing and distilling methanol/acetic acid/radioactive isotope solutions from gel electrophoresis studies and reusing the methanol.

Radioactive Material Use Modifications:

- Supercompaction of solid radioactive waste;
- Storing for decay short half-life radioactive or mixed waste.
- Use of 2.5-mL scintillation minivials rather than 10-mL (adapters available for 10-mL racks).
- Use of membranes to count cells, rather than scintillation fluid.

Other Possibilities:

- A change or simplification of procedure, e.g., eliminating the methanol gel fixing step in gel electrophoresis if it is not necessary (eliminates methanol, acetic acid and radioactive mixed waste).
- Use of microscaling techniques

REDUCE

Waste Minimization

Utilize chemical minimization (waste reduction) techniques to reduce the volume and toxicity of the wastes they generate. An important benefit derived from waste minimization is that it will reduce the University's waste disposal cost.

Chemical Redistribution

Unopened or unused portions of chemicals may be redistributed and used by another individual at the University.
It is a good practice to reduce scale of experiment as much as reasonable.

RECYCLE

Some experiments and analyses (e.g. column chromatography, liquid chromatography) produce large capacity of used slightly contaminated solvents. Sometimes it would be reasonable to recycle and re-use them in further work.

Annex I

PROPERTIES OF WASTES WHICH RENDER THEM HAZARDOUS

H1 'Explosive': substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

H2 'Oxidizing': substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.

H3-A 'Highly flammable':

— liquid substances and preparations having a flash point below 21ºC (including extremely flammable liquids), or

— substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or

— solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or

— gaseous substances and preparations which are flammable in air at normal pressure, or

— substances and preparations which, in contact with water or damp air,evolve highly flammable gases in dangerous quantities.

H3-B 'Flammable': liquid substances and preparations having a flash point equal to or greater than 21ºC and less than or equal to 55ºC.

H4 'Irritant': non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.

H5 'Harmful': substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.

H6 'Toxic': substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death.

H7 'Carcinogenic': substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.

H8 'Corrosive': substances and preparations which may destroy living tissue on contacts.

H10 'Teratogenic': substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.

H11 'Mutagenic': substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.

H12 Substances and preparations which **release toxic or very toxic gases in contact with water, air or an acid.**

H13 Substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above.

H14 'Ecotoxic': substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment.

B.

Wastes classified as hazardous are considered to display one or more of the properties listed in Annex III to Directive 91/ 689/EEC and, as regards H3 to H8, H10 (6) and H11 of that Annex, one or more of the following:

— flash point ≤ 55 °C,

— one or more substances classified (1) as very toxic at a total concentration ≥ 0,1 %,

— one or more substances classified as toxic at a total concentration ≥ 3 %,

— one or more substances classified as harmful at a total concentration ≥ 25 %,

— one or more corrosive substances classified as R35 at a total concentration ≥ 1 %,

— one or more corrosive substances classified as R34 at a total concentration ≥ 5 %,

— one or more irritant substances classified as R41 at a total concentration ≥ 10 %,

— one or more irritant substances classified as R36, R37, R38 at a total concentration ≥ 20 %,

— one or more substances known to be carcinogenic of category 1 or 2 at a total concentration ≥0,1%,

— one or more substances toxic for reproduction of category 1 or 2 classified as R60, R61 at a total concentration ≥ 0,5 %,

— one or more substances toxic for reproduction of category 3 classified as R62, R63 at a total concentration ≥ 5 %,

— one or more mutagenic substances of category 1 or 2 classified as R46 at a total concentration ≥ 0,1 %,

— one or more mutagenic substances of category 3 classified as R40 at a total concentration ≥ 1 %.

Annex II

TABLE I.

Before mixing any chemicals, refer to this partial list, the chemicals' MSDS' or ask your supervisor to verify compatibility:

CHEMICAL	INCOMPATIBILITY
Acetic acid	chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates, carbonates, phosphates
Acetone	acids (e.g. conc. nitric or sulfuric), amines, oxidizers, plastics, chloroform
Acetonitrile	nitric acid, elevated temperatures
Acetylene	halogens (chlorine, bromine, fluorine, etc.), copper, mercury, potassium, oxidizers, silver
Alkali and alkaline metals	water, carbon tetrachloride, chlorinated hydrocarbons, carbon dioxide, acids, chromium, ethylene, halogens, powdered metals(e.g. aluminum or magnesium), hydrogen, mercury, **earth** nitrogen, oxidizers, plastics, sodium chloride, sulfur
Ammonia	mercury (e.g. in manometers), halogens, hydrofluoric acid (anhydrous), chromium(VI) oxide, silver nitrate, aldehydes, amides, chlorosilicane, heavy metals, oxidizers, plastics, sulfur
Ammonium nitrate	Acetic acid, acids, alkalis, chloride salts, nitrates, sulfur, combustible materials, metals, organic materials, phosphorous, reducing agents, urea
Aniline	acids, aluminum, dibenzoyl peroxide, oxidizers, plastics
Azides	acids, heavy metals, oxidizers

CHEMICAL	INCOMPATIBILITY
Bromine	acetaldehyde, alcohols, alkalis, amines, combustible materials, ethylene, fluorine, hydrogen, ketones (acetone, carbonyls, etc.), metals, sulfur
Calcium oxide	acids, ethanol, fluorine, organic materials
Carbon (activated)	alkali metals, calcium hypochlorite, halogens, oxidizers
Carbon tetrachloride	benzoyl peroxide, ethylene, fluorine, metals, oxygen, plastics, silanes
Chlorates	powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid	acetone, alcohols, alkalis, ammonia, bases
Chromium trioxide	benzene, combustible materials, hydrocarbons, metals, organic materials, phosphorous, plastics
Chlorine	Alcohol's, ammonia, benzene, combustible materials, flammable compounds (hydrazine), hydrocarbons (acetylene, ethylene, etc.), hydrogen peroxide, iodine, metals, nitrogen, oxygen, sodium hydroxide
Chlorine dioxide	hydrogen, mercury, organic materials, phosphorous, potassium hydroxide, sulfur
Copper	Calcium, hydrocarbons, oxidizers
Hydroperoxide	reducing agents
Cyanides	acids, alkaloids, aluminum, iodine, oxidizers, strong bases
Flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Alcohol's, aldehydes, ammonia, combustible materials, halocarbons, halogens, hydrocarbons, ketones, metals, organic acids

CHEMICAL	INCOMPATIBILITY
Hydrocarbons (such as butane, propane benzene, turpentine, etc.)	acids, bases, oxidizers, plastics
Hydrofluoric acid	metals, organic materials, plastics, silica (glass), (anhydrous) sodium
Hydrogen peroxide	acetylaldehyde, acetic acid, acetone, alcohol's carboxylic acid, combustible materials, metals, nitric acid, organic compounds, phosphorous, sulfuric acid, sodium, aniline
Hydrogen sulfide	acetylaldehyde, metals, oxidizers, sodium
Hypochlorites	acids, activated carbon
Iodine	acetylaldehyde, acetylene, ammonia, metals, sodium
Mercury	acetylene, aluminum, amines, ammonia, calcium, fulminic acid, lithium, oxidizers, sodium
Nitrates	acids, nitrites, metals, sulfur, sulfuric acid
Nitric acid	acetic acid, acetonitrile, alcohol's, amines, (concentrated) ammonia, aniline, bases, benzene, cumene, formic acid, ketones, metals, organic materials, plastics, sodium, toluene
Oxalic acid	oxidizers, silver, sodium chlorite
Oxygen	acetaldehyde, secondary alcohol's, alkalis and alkalines, ammonia, carbon monoxide, combustible materials, ethers, flammable materials, hydrocarbons, metals, phosphorous, polymers
Perchloric acid	acetic acid, alcohols, aniline, combustible materials, dehydrating agents, ethyl benzene, hydriotic acid, hydrochloric acid, iodides, ketones, organic material, oxidizers, pyridine
Peroxides, organic	acids (organic or mineral)

CHEMICAL	INCOMPATIBILITY
Phosphorus (white)	oxygen (pure and in air), alkalis
Potassium	acetylene, acids, alcohols, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium chlorate	acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic materials, sugars
Potassium perchlorate (also see chlorates)	alcohols, combustible materials, fluorine, hydrazine, metals, organic matter, reducing agents, sulfuric acid
Potassium permanganate	benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Silver	acetylene, ammonia, oxidizers, ozonides, peroxyformic acid
Sodium	acids, hydrazine, metals, oxidizers, water
Sodium nitrate	acetic anhydride, acids, metals, organic matter, peroxyformic acid, reducing agents
Sodium peroxide	acetic acid, benzene, hydrogen sulfide metals, oxidizers, peroxyformic acid, phosphorous, reducers, sugars, water
Sulfides	acids
Sulfuric acid	potassium chlorates, potassium perchlorate, potassium permanganate

Material Safety Data Sheets, various chemical companies

Source: Michigan State University, Office of Radiation, Chemical and Biological Safety

7. References

1. J.P. Seiler, "Good Laboratory Practice, *The Why and the How",* Springer-Verlag Heildelberg, 2001

2. C.R. Asfahl, Industrial Safety and Health Management, Prientice Hall,Pearson, 2004

3. Z. Szafran, R.M.Pike, J.C. Foster, Microscale General Chemistry Laboratory, Willey,2003

Web pages:

http://somsafety.stanford.edu

http://lehigh.edu

http://www.udel.edu

http://www.ehs.ucla.edu

http://www.sepa.org.uk/guidance/waste/hazardous/

Hazardous Waste : Interpretation of the definition and classification of hazardous waste (www.environment-agency.gov.uk)